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Description

The present invention relates to a bioriented film, to a process for producing the bioriented film and to the use of the bioriented film for wrapping articles, such as consumer goods or food products.

Films used for wrapping articles such as consumer goods, for example books, records, compact discs, video cassettes, games, boxes etc., or food products such as fruits, pizzas, chocolate boxes etc., must be provided with a number of properties in order to meet the package requirements in terms of integrity and attractiveness. These properties mainly are

- excellent optical properties, i.e. high gloss, high clarity and low haze
- a balanced shrinkage in cross-direction and machine direction at low temperature and
- a low shrink tension.

Polyvinylchloride (PVC) films meet these requirements and are used to a great extent for wrapping consumer products. However, the environmental concerns about the extended use of PVC films are increasing and the toxic fumes emitted during the sealing of the PVC films can corrode the sealing bars. Therefore, the skilled artisans have tried to replace PVC films with other films having similar properties but causing less environmental concerns. Much research efforts have been spent on ethylene polymer films. Biaxially oriented tubular polyethylene films were found to usually have the required properties for wrapping articles.

U.S. Patents 4,354,997 and 4,463,153 disclose a process for producing biaxially oriented blown polyethylene films by biaxially stretching non-stretched tubular films produced from an ethylene polymer, such as low density polyethylene, linear low density polyethylene or a copolymer of ethylene as a main component and an alpha-olefinically unsaturated monomer. The non-stretched tubular film is expanded and extended under particular conditions at a special temperature profile simultaneously in the cross-direction and in the machine direction by means of an internal air pressure.

European Patent Application 0 240 705 relates to tubular heat shrinkable, biaxially stretched, blown films of a mixture of (A) 90 to 50 percent by weight of a linear ethylene/alpha-olefin copolymer having a density of 0.90 to 0.93 g/cm³ at 25°C and (B) 10 to 50 percent by weight of an ethylene polymer having a density of 0.87 to 0.91 g/cm³ at 25°C and less than the density of the copolymer (A) by at least 0.014 g/cm³. The non-stretched tubular film is expanded and stretched and, at the same time, biaxially oriented simultaneously in the cross-direction and machine direction by means of an air pressure in the tube.

British Patent specification 866,820 relates to films made of high or low pressure polyethylene, polypropylene or ethylene/propylene copolymers. The polymeric material which has been oriented by uni-axial or bi-axial stretching during its production is first subjected to high energy ionising irradiation. Then the material is heated and uni- or bi-axially oriented and finally cooled. A tubular film is used as a starting material for the first biaxial orientation. Due to the irradiation, the high temperature tensile strength of the film is increased. The biaxial orientation after irradiation is carried out by inflating the film with air or other gas or with a liquid to form a bubble. According to this bubble technique a blown film is produced which is simultaneously oriented in the cross-direction and in the machine direction.

U.S. Patent 4,680,207 relates to a biaxially oriented linear low density polyethylene film which has been stretched in the cross-direction at a stretching ratio of greater than 1 to less than 3 and in the machine at a stretching ratio of less than 6 but greater than the stretching ratio in the cross-direction. The film is produced as follows: a molten linear low density polyethylene which is optionally mixed with a low density non-linear polyethylene resin is extruded, blown to a film and biaxially oriented in special equipment. The film is useful for producing tubular and heavy duty shipping sacks.

For producing shrinkable films having high optical clarity, good shrink properties and good mechanical properties British Patent specification 2,097,324 suggests a film made by stretching a film made of the following homogeneous polymeric composition:

(1) 5 to 100 weight percent of a linear copolymer of ethylene with at least one C₈-C₁₈-alpha-olefin, said polymer having a density of 0.900 to 0.940 g/cm³ and two distinct crystallite melting regions below 128°C as determined by differential scanning calorimetry (DSC), the temperature difference between those regions being at least 15°C and

(2) 0 to 95 weight percent of at least one polymer selected from the group consisting of ethylene homopolymers and copolymers of ethylene with an ethylenically unsaturated comonomer, said polymer having only one crystallite melting point below 128°C.

The stretching of the film must be carried out within the temperature range defined by the two crystallite melting points of the copolymer (1). The polymers (2) are conventional ethylene homopolymers or copolymers. According to British Patent Specification 2,097,324 "conventional ethylene homopolymers or copolymers" are high density or low density polyethylene made at high pressure or low pressure. According to British Patent Specification 2,097,324 such conventional ethylene polymers having only one crystallite melting point below

128°C are not useful for producing the shrink films and linear copolymers of ethylene and 1-octene or another alpha-olefin wherein the alpha-olefin comonomer is present in such small amounts that a second DSC peak is not observed are not suitable for producing the shrink films either. The films are produced on a tubular film production line which combines the extrusion and the orientation of the film. British Patent 2,097,324 teaches by reference to U.S. Patent 3,141,912 that the tubular film is oriented by a combination of expansion and longitudinal stretching. The film is biaxially oriented in a continuous manner in two mutually perpendicular directions.

The ethylene polymers and polymer compositions disclosed in U.S. Patents 4,354,997, 4,463,153 and 4,680,207, in European Patent Application 0 240 705 and in British Patent specifications 866,820 and 2,097,324 are useful for producing films which are simultaneously bioriented in the machine direction and cross-direction. However, only blown tubular films can be bioriented according to the teaching in the above-mentioned publications. A special processing line is required for the biorientation process. The processing line must be able to maintain a permanent gas pressure inside the tubular film. The teaching of the above-mentioned publications is not useful for biorienting cast films or other flat, i.e. non-tubular films.

Flat films such as cast films are usually bioriented in at least two steps, first in one direction and then in the other direction. The inventors have tried to biorient, on a cast film production line, a flat film produced from the polymers disclosed in British Patent Specification 2,097,324. However, the produced films were found to be quite sensitive to minor changes of the processing conditions, such as the stretching temperature, the stretching ratio or the speed of the film production line.

European Patent Application 0212731 suggests the preparation of a mono-axially oriented cast film on the basis of an ethylene homo- or copolymer having a density below 940 kg/m³. The ethylene polymer may be blended with high density polyethylene or polypropylene and/or different types of ethylene homo- or copolymers having a low density may be blended. The use of low density ethylene homopolymers, optionally mixed with minor amounts of other ethylene polymers, for preparing the mono-axially oriented film is exemplified.

It would be desirable to provide a new bioriented film based on ethylene polymers which can be produced from a flat film according to a stretching process involving at least two orientation steps in which the processing conditions, such as temperature and stretching ratio, can be chosen within a relatively broad range and the process parameters may be changed to some extent during the stretching process without a substantial quality loss of the bioriented film. Furthermore, it would be desirable to provide a new process for producing bioriented films from flat films.

One aspect of the present invention is a mono- or multilayered bioriented cast film wherein the film-forming polymers of at least one layer are

(A) from 75 to 100 percent of at least one linear ethylene/alpha-olefin copolymer having a density of from 0.890 to 0.930 g/cm³ and

(B) from 25 to 0 percent of at least one high density linear polyethylene having a density of from 0.935 to 0.960 g/cm³,

all percentages being based on the total weight of (A) and (B),

with the proviso that the total of the film-forming polymers (A) and (B) has a single melting point as determined by differential scanning calorimetry according to ASTM D-3417.

The term "bioriented film" as used herein relates to films which, after they have been produced, are heated and mechanically oriented by stretching in the machine direction and in the cross-direction. It is understood in the art that the term "film orientation" refers to film drawing or stretching which occurs at a temperature below the crystalline melting point (T_c) and does not refer to the normal film drawing which occurs in the blown film process above T_c.

A further aspect of the present invention is a process for producing a mono- or multilayered bioriented film by orienting a flat mono- or multilayered film, wherein the film-forming polymers of at least one layer are the above-mentioned polymers (A) and (B), in at least two steps first in one direction and then in the other direction. The produced mono- or multilayered bioriented film preferably is a cast film.

Yet another aspect of the present invention is a process for packaging an article with the bioriented film of the present invention wherein the film is wrapped around the article, sealed and shrunk.

The film of the present invention has good mechanical and excellent optical properties, such as a high gloss, and good shrinkage in the machine and cross-direction as well as a low shrink tension. Furthermore, when producing a bioriented film according to the process of the present invention by biorienting a flat film, the processing conditions during the orientation are not very critical. Specifically, the orientation in the cross-direction of the film can occur within a wide temperature range and a wide range of stretching ratios while maintaining the good mechanical and optical properties of the film.

Figure 1 and 2 represent DSC curves of the polymers (A) used for producing the films of Examples 1 and 2. Figure 3 represents a DSC curve of a polymer (A) from which, after having blended it with a polymer (B), the film of Example 3 is produced. Figure 4 represents a DSC curve of a blend of polymer (A) and polymer (B)

used for producing the film of Example 3. Figure 5 represents a DSC curve of a blend of polymer (A) and polymer (B) used for producing the film of Example 5. Figure 6 represents a DSC curve of a linear low density polyethylene used for producing the film of Comparative Example A.

The film can be mono- or multilayered. The film-forming polymers of at least one layer must be the polymers (A) and, optionally, (B) in the amounts described below. A monolayered film or a multilayered film in which all layers contain the film-forming polymers (A) or (A) and (B) is preferred. The mentioned layer(s) have as film-forming polymers

(A) from 75 to 100 percent, preferably from 85 to 100 percent, more preferably from 95 to 100 percent and most preferably 100 percent of a linear ethylene/alpha-olefin copolymer having a density of from 0.890 to 0.930 g/cm³ and

(B) from 25 to 0 percent, preferably from 15 to 0 percent, more preferably from 5 to 0 percent and most preferably 0 percent of a high density linear polyethylene having a density of from 0.935 to 0.960 g/cm³.

The total of the film-forming polymers (A) and (B) must have a single melting point as determined by differential scanning calorimetry according to ASTM method D-3417.

It is possible to use linear ethylene/alpha-olefin copolymers having a density of from 0.890 to 0.930 g/cm³ which have two distinct crystallite melting regions, however, it has been found that in this case the ethylene/alpha-olefin copolymer (A) has to be blended with another polymer in order to allow biorientation of the film in a wide temperature range and a wide range of stretching ratios while maintaining good film properties. Surprisingly, it has been found that by blending a linear ethylene/alpha-olefin copolymer (A) having two distinct crystallite melting regions with a high density linear polyethylene (B) in a suitable weight ratio, polymer blends are obtained which have a single melting point as determined by differential scanning calorimetry and that such polymer compositions can easily be processed to bioriented films. The preferred weight ratios between a particular linear ethylene/alpha-olefin copolymer (A) and a particular high density polyethylene (B) can be determined by differential scanning calorimetry (DSC) according to ASTM method D-3417 by evaluating the DSC curves at different weight ratios between (A) and (B) and choosing those weight ratios which have a single melting point.

It is also possible to blend a linear ethylene/alpha-copolymer (A) having a density of from 0.890 to 0.930 g/cm³ and having a single melting point as determined by DSC with a high density linear polyethylene (B) provided that the blend of (A) and (B) has a single melting point.

Preferably, the linear ethylene/alpha-olefin copolymer (A) is not blended with any amount of high density linear polyethylene (B). In this case the linear ethylene/alpha-olefin copolymer (A) must have a single melting point as determined by DSC and in this case the low density linear copolymers of ethylene with at least one C₈₋₁₈-alpha-olefin disclosed in British Patent Specification 2,097,324 are not useful for the purpose of the present invention.

Non-oriented films, i.e. films which have not been stretched at a temperature below the crystalline melting point, produced of linear low density polyethylene (LLDPE) are known from various publications. The International Patent application WO 84/02707 discloses compression rolled films of LLDPE having a density of less than 0.94 g/cm³. The LLDPE can be blended with a high density polyethylene, a polypropylene or with an ethylene/propylene copolymer. The compression-rolling is carried out at 15 to 80°C. No substantial orientation is achieved by this process.

British Patent Application 2,066,271 relates to a polymer composition comprising (1) an ethylene/C₃-C₈-alpha olefin copolymer having an intrinsic viscosity of 1.3 to 8.7 dl/g and a density of 0.850 to 0.930 and (2) an ethylene polymer having a melt index of 0.01 to 0.2, a flow parameter of 1.9 to 2.8 and a density not lower than 0.940. The weight ratio between component, (1) and component (2) is 0.1 to 40: 99.9 to 60. The British Patent application teaches that the film forming property will be deteriorated if the polymer composition comprises more than 40 weight percent of component (1). A film is blown from the polymer composition which is not subjected to a subsequent orientation process.

European Patent application 0100689 relates to polyethylene compositions comprising

(A) from 60 to 90 weight percent of an ethylene/C₃₋₁₂-alpha-olefin having a density of from 0.905 to 0.925 g/cm³ and a melt index of from 0.5 to 2.5 dg/min and

(B) from 10 to 40 weight percent of an ethylene polymer having a density of from 0.95 to 0.97 g/cm³ and a melt index of from 0.05 to 1 dg/min.

The component (A) of the polymer composition preferably has an average content of a C₄₋₁₂-alpha-olefin of 1 to 8 mol percent and the alpha-olefin is heterogeneously distributed in the copolymer, the copolymer comprising crystalline and amorphous fractions. The European Patent application mentions that the polymers have improved extrusion stability and that the polymer composition can be extruded through a cylindrical or flat die. Blown films are extruded between 200 and 280°C. According to all examples blown films are produced. The

films are not subjected to a subsequent orientation process. The films are useful for producing heavy duty sacs, as stiff films for automatic packaging and as agricultural films.

However, it has been found that only those linear ethylene/alpha olefin copolymers (A) are useful for preparing bioriented films of good physical properties according to the process of the present invention if their density is not more than 0.930 g/cm³, preferably not more than 0.927 g/cm³ and more preferably not more than 0.920 g/cm³. Furthermore, only those linear ethylene/alpha olefin copolymers (A) are useful which have a single melting point or, if different types of copolymers (A) are mixed or if the linear ethylene/alpha-olefin copolymers (A) is (are) blended with a minor amount of one or more high density linear polyethylenes (B), only those polymer compositions of (A) and, optionally, (B) are useful which have a single melting point.

It has been found that the way of producing a linear ethylene/alpha-olefin copolymer (A) having a density of from 0.890 to 0.930 g/cm³ influences its melting behaviour. Catalyst composition, feed ratios of the monomers, the temperature and other processing conditions can significantly influence the distribution of the alpha-olefin in the copolymer chains. In those linear ethylene/alpha olefin copolymers (A) which have a single melting point as determined by DSC, the alpha-olefin is inhomogeneously distributed, that is some of the polyethylene chains contain many units which originate from the alpha-olefin and some of the polyethylene chains contain substantially no units which originate from the alpha-olefin. Useful alpha-olefins generally have 3 to 12 carbon atoms, preferably 3 to 8 carbon atoms. Preferred examples are stated below. The lower the amount of the alpha-olefin is, the higher is the density of the linear ethylene/alpha-olefin copolymer. The minimum average amount of the alpha-olefin comonomer has to be chosen in such a manner that the density of the linear ethylene/alpha-olefin copolymer is not more than 0.930 g/cm³. When the alpha-olefin comonomer is 1-octene, the linear ethylene/alpha-olefin copolymer must have an average 1-octene content of at least 3 percent, based on the total amount of ethylene and 1-octene. After copolymerisation of ethylene and the alpha-olefin the sufficient inhomogeneity of the alpha-olefin, that is the desired single melting point behaviour of the linear ethylene/alpha-olefin copolymer, can be examined by differential scanning calorimetry.

The linear ethylene/alpha-olefin copolymers having a density of from 0.890 to 0.930 g/cm³ are typically named in the literature "linear low density polyethylene" (LLDPE). By "linear low density polyethylene" (LLDPE) is meant normally solid ethylene polymers suitable for extrusion, casting, moulding or similar fabrication produced by polymerisation of ethylene with up to 25 percent by weight of the polymer of at least one alpha-olefin having from 3 to 12, preferably 4 to 8, carbon atoms per olefin molecule.

The useful LLDPE copolymers are for example those which are prepared using coordination catalysts, for example the well known Ziegler, Natta or Phillips catalysts or preferably the catalyst compositions described in British Patent Specification 1,500,873. The LLDPE copolymers include those made at low, intermediate or high pressures in solution and gas phase processes. These ethylene polymers contain up to 25 percent, generally from 3 to 20 percent, preferably from 4 to 17 percent, more preferably from 5 to 15 percent, by weight of at least one alpha-olefin comonomer which is preferably selected from the group consisting of propylene, 1-butene, 1-isobutene, 4-methyl-1-pentene, 1-pentene, 1-isopentene, 1-hexene, 1-isohexene, 1-heptene, 1-isohexene, 1-octene, 1-isooctene, 1-nonene, 1-isononene, 1-decene and 1-isodecene. 1-Hexene, 4-methyl-1-pentene, 1-butene, propylene and in particular 1-octene are the most preferred comonomers. The amount of comonomers should be enough to result in polymer densities of 0.890 to 0.930 g/cm³, preferably from 0.900 to 0.927 g/cm³ and more preferably from 0.910 to 0.920 g/cm³. The copolymers generally have a high molecular weight and have a melt index (melt flow) in the range of 0.1 to 30 dg/min., preferably of from 1 to 20 dg/min., more preferably of from 2 to 6 dg/min., as measured by ASTM-D-1238, condition (E).

The linear polyethylene (B) which has a density of from 0.935 to 0.960 g/cm³, preferably from 0.940 to 0.960 g/cm³, is well known in the Art as high density polyethylene (HDPE). Generally, the linear polyethylene (B) has a melt index of from 0.5 to 25 dg/min., preferably of from 1 to 10 dg/min.. HDPE includes the linear polymers made at low pressure using a coordination catalyst such as a "Ziegler-type" catalyst. Methods of preparing such polymers are well known in the art, for example as taught by Schildknecht, Polymer Processes Vol. X (1956) or in Chem. Eng. News, 5 December 1977. The HDPE is preferably produced according to a solution polymerization process.

The bioriented film of the present invention preferably consists of a single layer or of several layers which all contain the film-forming polymers (A) and, optionally, (B) as described above. However, a multilayered bioriented film may also contain one or more layers of a known polymer or polymer composition, such as polypropylene, polybutene, a blend of polypropylene and polybutene or a blend of polypropylene and/or polybutene with polyethylene provided that such additional layers do not cause substantial difficulties in the process for producing the films and do not deteriorate the properties of the bioriented film.

The bioriented film of the present invention can contain known additives, such as slip agents, for example erucamide or oleamide, antiblock agents such as silica or well-known antistatic agents. Such additives are generally present in amounts of no more than 5 percent by the weight of the film-forming polymers (A) and

(B).

The above described polymer (A), optionally blended with a polymer (B) and/or optional additives, can be fabricated to a film or sheet in a known manner. A flat cast film or sheet can be produced from the molten polymers in a known manner. Known coextrusion techniques can be applied for producing multilayered films or sheets wherein the film-forming polymers of at least one layer are the polymer(s) (A) and, optionally, (B) described above.

In the practice of producing a sheet or film, the polymers are extruded through a flat die for producing a cast film or sheet. The extrusion temperature generally is more than 200°C, preferably from 220 to 265°C. The extruded film preferably has a thickness of from 100 to 2000 micrometers, more preferably from 400 to 1000 micrometers prior to biorientation.

For producing cast films the polymers are preferably extruded through the flat die onto a chill roll which preferably is immersed in water in order to chill the produced cast film. The temperature of the cast film on the chill roll generally is from 20 to 90°C, preferably from 50 to 80°C. The temperature of the water bath preferably is 25°C or less.

The cast flat mono- or multilayered film is then bioriented in at least two steps. The orientations in the machine direction and in the cross-direction are carried out separately, that is first in the machine direction and then in the cross-direction or vice versa. Between the orientation in the machine direction and the orientation in the cross-direction the film is cooled. Although the film can be stretched in the cross-direction first and then in the machine direction, it is preferred to stretch the film in the machine direction first.

The stretching in the machine direction can be carried out by passing the film through a set of heated rollers revolving at different speed. The heated rollers may have different temperatures. The stretching in the machine direction is typically carried out at a temperature of from 90 to 120°C, preferably from 95 to 115°C, more preferably from 100 to 110°C. The stretching ratio in the machine direction preferably is from 3:1 to 8:1, more preferably from 5:1 to 7:1. The film is then cooled, typically to a temperature between 80 and 100°C, preferably between 85 and 95°C, for example by passing the film over another set of rollers in order to avoid too much relaxation.

The film is then reheated and stretched in the cross-direction. The stretching in the cross-direction is generally carried out in a tenter frame oven. Tenter frame ovens are known in the Art. Typically, a tenter frame oven contains six heating zones of which two zones are used for preheating the film, in the following two zones the film is stretched in the cross-direction and in the last two zones the film is relaxed and annealed. The tenter frame oven may have additional zones. When orienting in cross-direction a film produced of the low density linear copolymers of ethylene with of at least one C_{8-18} alpha-olefin disclosed in British Patent Specification 2 097 324 having two distinct crystallite melting regions, the preheating temperature in the oven is extremely critical to the consistent production of films with good optical properties. It has been found that a deviation of -1°C from the optimum preheating temperature causes film breakage whereas a deviation of +1°C from the optimum preheating temperature causes the film to have a "milky" or hazy appearance. Even slight changes in the heat transfer conditions brought about by changes in the speed of hot air fans in the oven have been found sufficient to cause either film breakage or films with milky appearance when using the low density linear ethylene/alpha-olefin copolymers described in the above-mentioned British patent.

This is not the case for the polymer (composition) (A) and optionally (B) used for producing the films of the present invention. Surprisingly, it has been found that when producing the films of the present invention, the preheating temperature in the cross-orienting step can be chosen in quite a wide range while still allowing a consistent film production resulting in films with excellent clarity and gloss. Generally, the preheating temperature can be chosen in the range of from 125 to 145°C, preferably from 130 to 140°C and more preferably from 135 to 140°C. These preheating temperatures are particularly preferred for those above described linear ethylene/alpha-olefin copolymers (A) which have a density of from 0.917 to 0.920 g/cm³. After having preheated the film, the film is stretched in the cross-direction, generally at a temperature of from 90 to 120°C, preferably from 95 to 115°C, more preferably from 100 to 110°C. The stretching ratio in the cross-direction preferably is from 6:1 to 9:1, more preferably from 7:1 to 8:1, for obtaining balanced shrink properties of the film. The film is then usually annealed at a temperature of from 80 to 110°C, preferably from 85 to 100°C.

The film is generally oriented once in the machine direction and once in the cross-direction. However, if desired in special cases, the film can be oriented twice or more times in the machine direction and/or twice or more times in the cross-direction. The film may then be cooled, preferably to ambient temperature and then wound onto a roll. The bioriented film preferably has a thickness of from 5 to 100 micrometers, preferably from 10 to 60 micrometers, more preferably from 15 to 40 micrometers.

The bioriented film of the present invention can be used for packaging articles, such as food or other consumer goods, by wrapping the film around the article, sealing the film and then shrinking the film around the

article. For example, a known hot wire sealing system can be used for sealing. The film can be shrunk in a shrink tunnel or a shrink oven which is known in the art.

The invention is further illustrated by the following examples which should not be construed to limit the scope of the invention. All parts and percentages are by weight unless otherwise mentioned. All linear ethylene/1-octene copolymers (LLDPE) in the Examples contain erucamide as a common slip agent.

Example 1

10 A monolayered film is produced by
 i) extruding a linear ethylene/1-octene copolymer (LLDPE) having a density of 0.917 g/cm³, measured according to ASTM method D-792, a nominal 1-octene content of 7 percent, determined by infrared measurement according to ASTM D-2238-B, a single melting point measured by DSC according to ASTM D-3417 and a melt index of 2.3 dg/min., measured according to ASTM-D-1238, condition E, at a temperature
 15 of 260 °C through a flat die in a Bruckner film production line, and
 ii) chilling the film on a chill roll to a temperature of 60°C, the chill roll being immersed in a water bath of 26°C.
 The produced cast film is then bioriented by
 a) heating the film to varying temperatures of 100°C to 116°C on oil-heated rollers,
 20 b) stretching the film in the machine-direction at a stretching ratio of 5.8:1 by passing the film over heated rollers revolving a different speed, the temperature of the rollers prior to stretching being 111°C and the temperature of the rollers after stretching being 105°C,
 c) cooling the stretched film to a temperature of 90°C by passing the film over another set of rollers,
 25 d) preheating the film in a tenter frame oven having two preheating zones in which the temperatures are 138°C and 137°C, stretching the film at a stretching ratio of 8:1 in the cross-direction in the two stretching zones of the tenter frame oven in which the temperatures are 110°C and 101°C and relaxing the film in the two relaxation zones of the tenter frame oven at a temperature of 100°C, and
 e) cooling the film and winding it onto a roll.
 The produced bioriented film has a thickness of 17 micrometers.

Example 2a

35 Example 1 is repeated, however, a linear ethylene/1-octene copolymer (LLDPE) having a density of 0.917 g/cm³, a nominal 1-octene content of 7 percent, a single melting point and a melt index of 3.3 dg/min. is used for producing the monolayered bioriented film. The extrusion temperature is 256°C and the stretching ratio in the cross-direction is 7.8:1.

Example 2b

40 Example 2a is repeated, however the stretching ratio in the machine direction is 4.9:1 and the stretching ratio in the cross-direction is 8.2:1.

Example 3

45 Example 1 is repeated, however, a bioriented film having a thickness of 30 micrometers is produced from a blend of

(A) 78 percent of a linear ethylene/1-octene copolymer having a density of 0.912 g/cm³, a nominal 1-octene content of 10 percent, two melting points and a melt index of 3.3 dg/min. (LLDPE) and
 50 (B) 22 percent of a HDPE produced by solution polymerization having a density of 0.955 g/cm³ and a melt index of 4.0 dg/min.,

based on the total weight of (A) and (B). The polymer blend (A)/(B) has a single melting point.

The extrusion temperature is 256°C and the film is stretched in the machine direction at roller temperatures of 115°C and 105°C at a stretching ratio of 5.7:1. The temperatures of the stretching zones in the tenter frame oven are 110°C and 100°C.

Example 4

55 Example 1 is repeated, however, a bioriented film having a thickness of 30 micrometers is produced. The extrusion temperature is 262°C, the film is stretched in the machine direction at roller temperatures of 115°C

and 105°C, preheated in the tenter frame oven to 140°C/139°C and stretched in the cross-direction at 112°C/101°C at a stretching ratio of 7.7:1.

5 Example 5

Example 3 is repeated, however, a bioriented film having a thickness of 30 micrometers is produced from a blend of

- 10 (A) 85 percent of the linear ethylene/1-octene copolymer used in Example 3 and
(B) 15 percent of the HDPE used in Example 3. The extrusion temperature is 255°C and the roller temperatures when stretching in the machine direction are 111°C and 105°C.

Comparative Example A

- 15 Example 1 is repeated, however a linear ethylene/1-octene copolymer (LLDPE) having a density of 0.917 g/cm³, a nominal 1-octene content of 7 to 8 percent, a melt index of 2.3 dg/min. and two melting points is used for producing the monolayered bioriented film. The LLDPE is commercially available as DOWLEX 2047E. The stretching ratio in the machine direction is 5.0:1 and the roller temperature prior to and after stretching is 104°C. The stretching ratio in the cross-direction is 7.8:1. The temperature in both preheating zones of the tenter frame oven is 139°C. The temperatures in the two stretching zones in the tenter frame oven are 110°C and 101°C.

Comparative Example B

- 25 Comparative Example A is repeated, however the temperature in both preheating zones of the tenter frame oven is 138°C. The film breaks.

Comparative Example C

- 30 Comparative Example A is repeated, however the temperature in both preheating zones of the tenter frame oven is 140°C. The produced film has a "milky" or hazy appearance and is not useful for packaging purposes.

The melting points of the polymers used in Examples 1 to 3 and 5 and in comparative Example A are determined by differential scanning calorimetry (DSC) according to ASTM-D-3417 using a Perkin-Elmer calorimeter. The DSC curves are shown in Figure 1 to 6.

Table I

<u>Example</u>	<u>Polymer</u>	<u>Figure</u>	<u>Melting behaviour</u>
1	LLDPE	1	Single melting point
2	LLDPE	2	Single melting point
3*	100% LLDPE	3	Two melting points
3	78% LLDPE and 22% HDPE	4	One single melting point
5	85% LLDPE and 15% HDPE	5	one single melting point
A**	LLDPE	6	Two melting points

55 *LLDPE (A) used in the blend of Example 3; a film made of 100 percent of the LLDPE (A) is not in the scope of the invention.

**Not an Example of the Invention

Examples 6 to 8

Example 2a is repeated, however the stretching ratio in the machine direction and the stretching temperatures in the cross-direction are varied. The processing conditions are summarized in Table II below.

Examples 2a, 2b and 6 to 8 illustrate that the bioriented films of the present invention can be consistently produced and the produced films have good optical properties even when the stretching ratios and stretching temperatures are substantially varied.

The processing conditions for producing the films of Examples 1 to 8 and of Comparative Example A, the physical appearance of the films and the measured

The processing conditions for producing the films of Examples 1 to 8 and of comparative Example A, the physical appearance of the films and the measured physical properties of the films of Examples 1 to 5 and comparative Example A are listed in Table II below.

The 60° gloss is measured according to ASTM-D-2457.

The haze in percent is measured according to ASTM-D-1003.

The clarity in percent is measured according to ASTM-D-1746.

The Elmendorf tear strength is measured in machine-direction (MD) and in cross-direction (CD) according to ASTM-D-1922.

The puncture resistance/puncture energy is measured as follows:

A film sample which is about 200 mm x 200 mm is clamped in a circular clamping system of a diameter of 125 mm. The film must be without wrinkles. An aluminum plunger with a rounded tip of a diameter of 12.5 mm and attached to a load cell is brought against the film such that it is just touching. The plunger then advances into the film at a speed of 500 mm/min. until the film punctures. During this time a plotter continuously records the force and the distance moved by the plunger. The maximum force at puncture is recorded in N along with the extension of the film at puncture in mm. The puncture energy in joules is recorded by measuring the total area under the force/extension curve made by the plotter. The average puncture energy for five film samples is listed in Table II.

The free shrinkage in percent is measured as follows:

Five film samples are cut, each measuring 100 mm x 5 mm. A sample is then immersed in a silicon oil bath at the desired temperature for 15 seconds. The sample is then removed and placed in a water bath at 23°C to cool down. The length and width of the sample is measured and the shrinkage is recorded as percentage. This procedure is repeated with the other four samples and the average shrinkage at 4 different temperatures is listed in Table II.

The shrink tension is measured as follows:

Five film samples, each 100 mm x 15 mm, are prepared. Each film sample is then fixed in a clamping system such that the clamps are 87 mm apart. The film sample is then immersed in a silicon oil bath held at 130°C for 10 seconds. The clamps are then moved to their original position and a plotter records the development of the shrink tension. The average shrink tension (in N/mm²) is listed in Table II.

Table II

EXAMPLES

processing conditions	<u>1</u>	<u>2 a</u>	<u>2 b</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>Comp. Ex. A</u>	<u>6</u>	<u>7</u>	<u>8</u>
Film thickness (micrometers)	17	17	17	30	30	30	17	17	17	17
Melt temp. (extrusion temp.) °C	260	256	256	256	262	255	260	256	256	256
Machine direction stretching										
- Ratio	5.8:1	5.8 : 1	4.9 : 1	5.7:1	5.8 : 1	5.7:1	5.0:1	5.5:1	5.5:1	6.8:1
- roller temp. °C	111/105	111/105	111/105	115/105	115/105	111/105	104/104	100/90	100/90	100/90
to/after shrinkage										
Cross direction stretching										
- Ratio	8:1	7.8 : 1	8.2:1	8:1	7.7:1	8:1	7.8:1	9:1	9:1	9:1
- preheating temp. °C	138/137	138/137	138/137	138/137	140/139	138/137	139/139	126/133	141/135	135/132
- stretching temp. °C	110/101	110/101	110/101	110/100	112/101	110/100	110/101	106/98	106/98	105/100
- relaxation temp. °C	100	100	100	100	100	100	100	100	100	100

Table II continued

EXAMPLES									
processing conditions	1	2 a	2 b	3	4	5	Comp. Ex. A	6	7
film properties									
Visual film appearance	excel- lent	excel- lent	excel- lent	good	excel- lent	excel- lent	very good, but sensitive to process cond. (see comp. Ex. B and C)	excel- lent	excel- lent
Gloss 60° %	167	165	167	104	159	159	153		
Haze %	1.2	1.1	1.0	4	1.7	1.7	1.7		
Clarity %	78	89	89	72	86	85	90		
Elmendorf MD	13	11	11	20	22	20	10		
tear (g)	8	8	7	8	12	10	9		
CD									
Puncture energy J	0.65	0.7	0.6	1.5	1.5	1.4	0.55		
Shrinkage % MD/CD									
90°C									
100°C	9/14	8/13	8/13	7/14	8/12	8/13	7/15		
110°C	13/23	12/24	11/23	9/22	12/23	12/24	11/28		
120°C	26/40	24/43	16/37	28/52	20/39	43/47	21/46		
	60/65	59/67	53/68	45/63	58/65	52/66	-----		
Shrink tension									
MD/CD 100°C N/mm ²	0.8/1.3	0.8/1.4	0.8/1.3	1.4/2.3	1.0/1.5	1.0/1.6	3.8/1.5		

Claims

1. A mono- or multilayered bioriented cast film wherein the film-forming polymers of at least one layer are

- (A) from 75 to 100 percent of at least one linear ethylene/alpha-olefin copolymer having a density of from 0.890 g/cm³ to 0.930 g/cm³ and
 (B) from 25 to 0 percent of at least one high density linear polyethylene having a density of from 0.935 g/cm³ to 0.960 g/cm³,
 all percentages being based on the total weight of (A) and (B),
 wherein the film has been stretched at a stretching ratio of from 3 : 1 to 8 : 1 in the machine direction and from 6 : 1 to 9 : 1 in the cross-direction,
 with the proviso that the total of the film-forming polymers (A) and (B) has a single melting point as determined by differential scanning calorimetry according to ASTM D-3417.
2. The bioriented film of claim 1 wherein the film-forming polymers of at least one layer are
 (A) from 85 to 100 percent, preferably from 95 to 100 percent, of the linear ethylene/alpha-olefin copolymer and
 (B) from 15 to 0 percent, preferably from 5 to 0 percent, of the high density linear polyethylene.
 3. The bioriented film of Claim 1 or 2 wherein the linear ethylene/alpha-olefin copolymer (A) had a density of from 0.900 g/cm³ to 0.927 g/cm³, preferably of from 0.910 g/cm³ to 0.927 g/cm³.
 4. The bioriented film of any one of Claims 1 to 3 wherein the alpha-olefin is propylene, 1-butene, 1-isobutene, 4-methyl-1-pentene, 1-pentene, 1-isopentene, 1-hexene, 1-isohexene, 1-heptene, 1-isohexene, 1-octene, 1-isooctene, 1-nonene, 1-isononene, 1-decene or 1-isodecene.
 5. The bioriented film of any one of Claims 1 to 3 wherein the alpha-olefin is 1-octene.
 6. The bioriented film of any one of Claims 1 to 5 which is stretched at a stretching ratio of from 5 : 1 to 7 : 1 in the machine direction and from 7 : 1 to 8 : 1 in the cross-direction.
 7. A process for producing the bioriented film of claim 1, wherein a cast mono- or multilayered film is oriented in at least two steps, first in one direction and then in the other direction, in a stretching ratio of from 3 : 1 to 8 : 1 in the machine direction and from 6 : 1 to 9 : 1 in the cross-direction, the film-forming polymers of at least one layer being
 (A) from 75 to 100 percent of at least one linear ethylene/alpha-olefin copolymer having a density of from 0.890 g/cm³ to 0.930 g/cm³ and
 (B) from 25 to 0 percent of at least one high density linear polyethylene having a density of from 0.935 g/cm³ to 0.960 g/cm³,
 all percentages being based on the total weight of (A) and (B),
 with the proviso that the total of the film-forming polymers (A) and (B) has a single melting point as determined by differential scanning calorimetry according to ASTM D-3417.
 8. The process of Claim 7 for producing the bioriented film of any one of claims 1 to 6.
 9. The process of Claim 7 or 8 wherein the film is first oriented in the machine direction and then in the cross-direction.
 10. The process of any one of Claims 7 to 9 wherein the film is oriented in the machine direction by means of a set of heated rollers revolving at different speeds and the film is oriented in the cross-direction in a tenter frame oven.
 11. The process of any one of Claims 7 to 10 wherein the film is stretched in the machine direction at a temperature of from 90°C to 120°C and thereafter in the cross-direction by preheating it to a temperature of from 125°C to 145°C, stretching it in the cross-direction at a temperature of from 90°C to 120°C and annealing it to a temperature of from 80°C to 110°C.
 12. A process for packaging an article with the bioriented film of any one of Claims 1 to 6 wherein the film is wrapped around the article, sealed and shrunk.

Patentansprüche

1. Ein- oder mehrschichtige biaxial gereckte Gießfolie, worin die folienbildenden Polymere von mindestens einer Schicht sind
 (A) von 75 bis 100 % von mindestens einem Copolymer aus linearem Ethylen/ α -Olefin mit einer Dichte von 0,890 g/cm³ bis 0,930 g/cm³ und
 (B) von 25 bis 0 % von mindestens einem hochdichten linearen Polyethylen mit einer Dichte von 0,935 g/cm³ bis 0,960 g/cm³,
 wobei alle Prozentwerte auf das Gesamtgewicht von (A) und (B) bezogen sind,
 worin die Folie mit einem Dehnungsverhältnis von 3:1 bis 8:1 in der Maschinenrichtung und von 6:1 bis 9:1 in der Querrichtung gedehnt worden ist,
 unter der Voraussetzung, daß die Gesamtheit der folienbildenden Polymere (A) und (B) einen einzigen Schmelzpunkt nach Bestimmung durch differentielle Scanner-Kalorimetrie gemäß ASTM D-3417 aufweist.
2. Biaxial gereckte Folie nach Anspruch 1, worin die folienbildenden Polymere von mindestens einer Schicht sind
 (A) von 85 bis 100 %, vorzugsweise von 95 bis 100 % des Copolymers aus linearem Ethylen/ α -Olefin und
 (B) von 15 bis 0 %, vorzugsweise von 5 bis 0 % des hochdichten linearen Polyethylens.
3. Biaxial gereckte Folie nach Anspruch 1 oder 2, worin das Copolymer (A) aus linearem Ethylen/ α -Olefin eine Dichte von 0,900 g/cm³ bis 0,927 g/cm³, vorzugsweise von 0,910 g/cm³ bis 0,920 g/cm³ aufweist.
4. Biaxial gereckte Folie nach einem der Ansprüche 1 bis 3, worin das α -Olefin Propylen, 1-Buten, 1-Isobuten, 4-Methyl-1-penten, 1-Penten, 1-Isopenten, 1-Hexen, 1-Isohexen, 1-Hepten, 1-Isohepten, 1-Octen, 1-Isoocten, 1-Nonen, 1-Isononen, 1-Decen oder 1-Isodecen ist.
5. Biaxial gereckte Folie nach einem der Ansprüche 1 bis 3, worin das α -Olefin 1-Octen ist.
6. Biaxial gereckte Folie nach einem der Ansprüche 1 bis 5, die mit einem Dehnungsverhältnis von 5:1 bis 7:1 in der Maschinenrichtung und von 7:1 bis 8:1 in der Querrichtung gedehnt ist.
7. Verfahren zur Herstellung der biaxial gereckten Folie nach Anspruch 1, worin eine ein- oder mehrschichtige Gießfolie in mindestens zwei Schritten gereckt wird, zuerst in einer Richtung und dann in der anderen Richtung, in einem Dehnungsverhältnis von 3:1 bis 8:1 in der Maschinenrichtung und von 6:1 bis 9:1 in der Querrichtung, wobei die folienbildenden Polymere von mindestens einer Schicht sind,
 (A) von 75 bis 100 % von mindestens einem Copolymer aus linearem Ethylen/ α -Olefin mit einer Dichte von 0,890 g/cm³ bis 0,930 g/cm³ und
 (B) von 25 bis 0 % von mindestens einem hochdichten linearen Polyethylen mit einer Dichte von 0,935 g/cm³ bis 0,960 g/cm³,
 wobei alle Prozentwerte auf Basis des Gesamtgewichts von (A) und (B) sind,
 unter der Voraussetzung, daß die Gesamtheit der folienbildenden Polymere (A) und (B) einen einzigen Schmelzpunkt nach Bestimmung durch differentielle Scanner-Kalorimetrie gemäß ASTM D-3417 aufweist.
8. Verfahren nach Anspruch 7 zur Herstellung der biaxial gereckten Folie nach einem der Ansprüche 1 bis 6.
9. Verfahren nach Anspruch 7 oder 8, worin die Folie zuerst in der Maschinenrichtung und dann in der Querrichtung gereckt wird.
10. Verfahren nach einem der Ansprüche 7 bis 9, worin die Folie in der Maschinenrichtung mittels eines Satzes von geheizten Rollen, die sich bei verschiedenen Geschwindigkeiten drehen, gereckt wird und die Folie in der Querrichtung in einem Spannrahmenofen gereckt wird.
11. Verfahren nach einem der Ansprüche 7 bis 10, worin die Folie in der Maschinenrichtung bei einer Temperatur von 90°C bis 120°C und danach in der Querrichtung durch Vorheizen auf eine Temperatur von 125°C bis 145°C, Dehnen in der Querrichtung bei einer Temperatur von 90°C bis 120°C und Tempern auf

eine Temperatur von 80°C bis 110°C gedehnt wird.

12. Verfahren zum Verpacken eines Gegenstandes mit der biaxial gereckten Folie nach einem der Ansprüche 1 bis 6, worin die Folie um den Gegenstand gewickelt, abgedichtet und geschrumpft wird.

Revendications

1. Film coulé biorienté à une ou plusieurs couches, dans lequel au moins une couche est constituée des polymères filmogènes suivants :
 - (A) de 75 à 100% d'au moins un copolymère linéaire éthylène/alpha-oléfine ayant une densité comprise entre 0,890 et 0,930 g/cm³, et
 - (B) de 25 à 0% d'au moins un polyéthylène linéaire à haute densité ayant une densité comprise entre 0,935 et 0,960 g/cm³;
 tous les pourcentages étant définis par rapport au poids total des polymères (A) et (B);
 ledit film ayant été étiré à un taux d'étirage de 3:1 à 8:1 dans le sens machine et de 6:1 à 9:1 dans le sens transversal;
 sous réserve que la totalité des polymères filmogènes (A) et (B) présente un point de fusion unique déterminé par analyse enthalpique différentielle selon la norme ASTM D-3417.
2. Film biorienté selon la revendication 1, dans lequel au moins une couche est constituée des polymères filmogènes suivants :
 - (A) de 85 à 100%, de préférence de 95 à 100%, de copolymère linéaire éthylène/alpha-oléfine, et
 - (B) de 15 à 0%, de préférence 5 à 0%, de polyéthylène linéaire à haute densité.
3. Film biorienté selon la revendication 1 ou 2, dans lequel le copolymère (A) linéaire éthylène/alpha-oléfine a une densité comprise entre 0,900 et 0,927 g/cm³, de préférence entre 0,910 et 0,920 g/cm³.
4. Film biorienté selon l'une quelconque des revendications 1 à 3, où l'alpha-oléfine est le propylène, le butène-1, l'isobutène-1, le méthyl-4 pentène-1, le pentène-1, l'isopentène-1, l'hexène-1, l'isohexène-1, l'heptène-1, l'isoheptène-1, l'octène-1, l'isooctène-1, le nonène-1, l'isononène-1, le décène-1, l'isodécène-1.
5. Film biorienté selon l'une quelconque des revendications 1 à 3, où l'alpha-oléfine est l'octène-1.
6. Film biorienté selon l'une quelconque des revendications 1 à 5, où celui-ci est étiré à un taux d'étirage compris entre 5:1 et 7:1 dans le sens machine et entre 7:1 et 8:1 dans le sens transversal.
7. Procédé de préparation d'un film biorienté selon la revendication 1, dans lequel on oriente un film coulé à une ou plusieurs couches en au moins deux étapes, la première dans une direction et ensuite dans une autre direction, avec un taux d'étirage compris entre 3:1 et 8:1 dans le sens machine et entre 6:1 et 9:1 dans le sens transversal;
 - une couche, au moins, étant constituée des polymères filmogènes suivants :
 - (A) de 75 à 100% d'au moins un copolymère linéaire éthylène/alpha-oléfine ayant une densité comprise entre 0,890 et 0,930 g/cm³, et
 - (B) de 25 à 0% d'au moins un polyéthylène linéaire à haute densité ayant une densité comprise entre 0,935 et 0,960 g/cm³;
 tous les pourcentages étant définis par rapport au poids total des polymères (A) et (B);
 sous réserve que la totalité des polymères filmogènes (A) et (B) ait un point de fusion unique déterminé par analyse enthalpique différentielle selon la norme ASTM D-3417.
8. Procédé selon la revendication 7, pour préparer le film biorienté selon l'une quelconque des revendications 1 à 6.
9. Procédé selon la revendication 7 ou 8, dans lequel le film est orienté dans un premier temps dans le sens machine puis dans le sens transversal.
10. Procédé selon l'une quelconque des revendications 7 à 9, dans lequel le film est orienté dans le sens machine au moyen d'un ensemble de rouleaux chauffés tournant à différentes vitesses, puis orienté dans

le sens transversal dans un four à cadre extenseur.

5 **11.** Procédé selon l'une quelconque des revendications 7 à 10, dans lequel le film est étiré dans le sens machine à une température de 90 à 120°C et ensuite en préchauffant celui-ci à une température de 125 à 145°C, on l'étire dans le sens transversal à une température de 90 à 120°C, puis on le recuit à une température de 80 à 110°C.

10 **12.** Procédé pour emballer un article avec un film biorienté selon l'une quelconque des revendications 1 à 6, dans lequel le film est enroulé autour de l'article, scellé et fritté.

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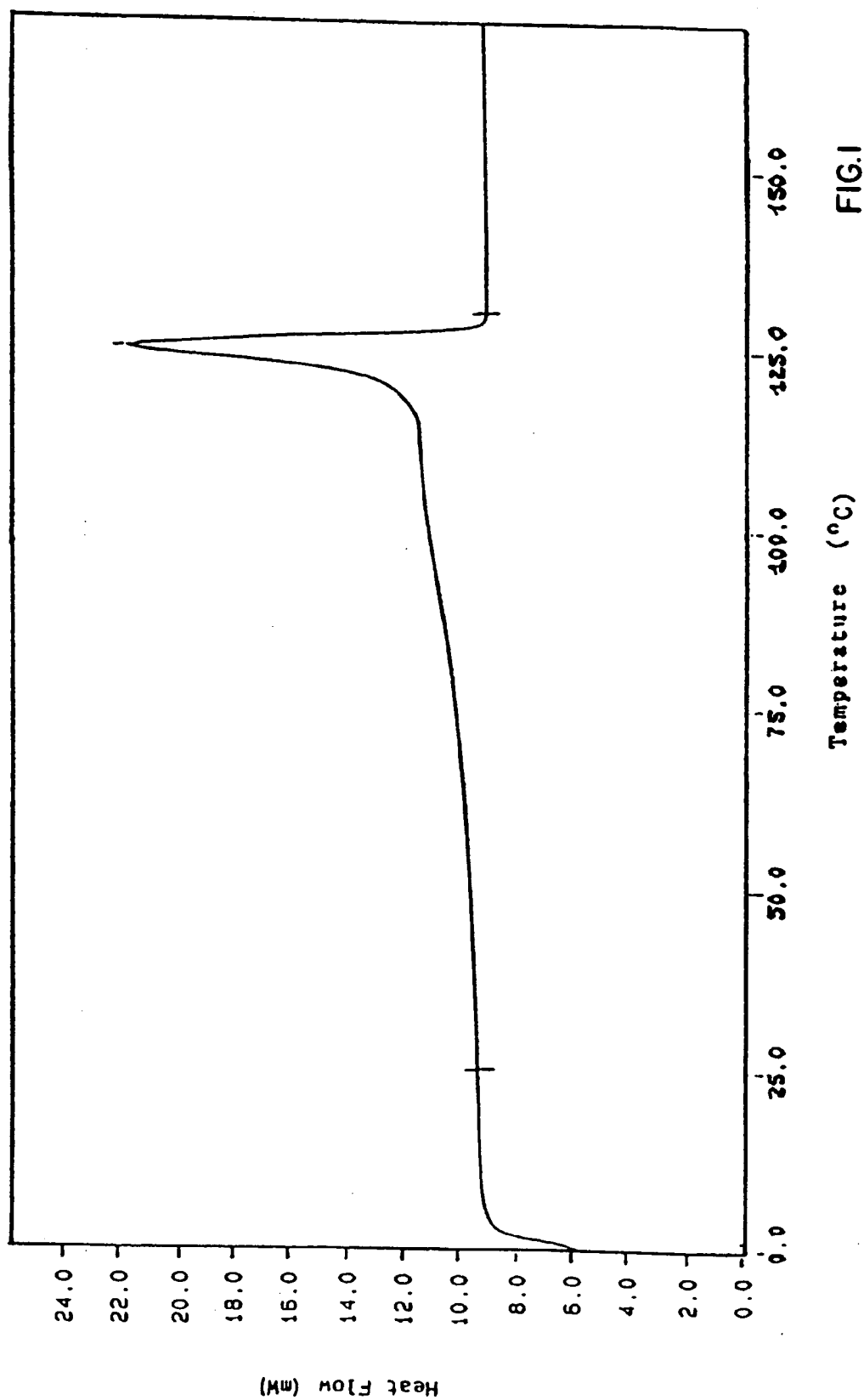


FIG.1

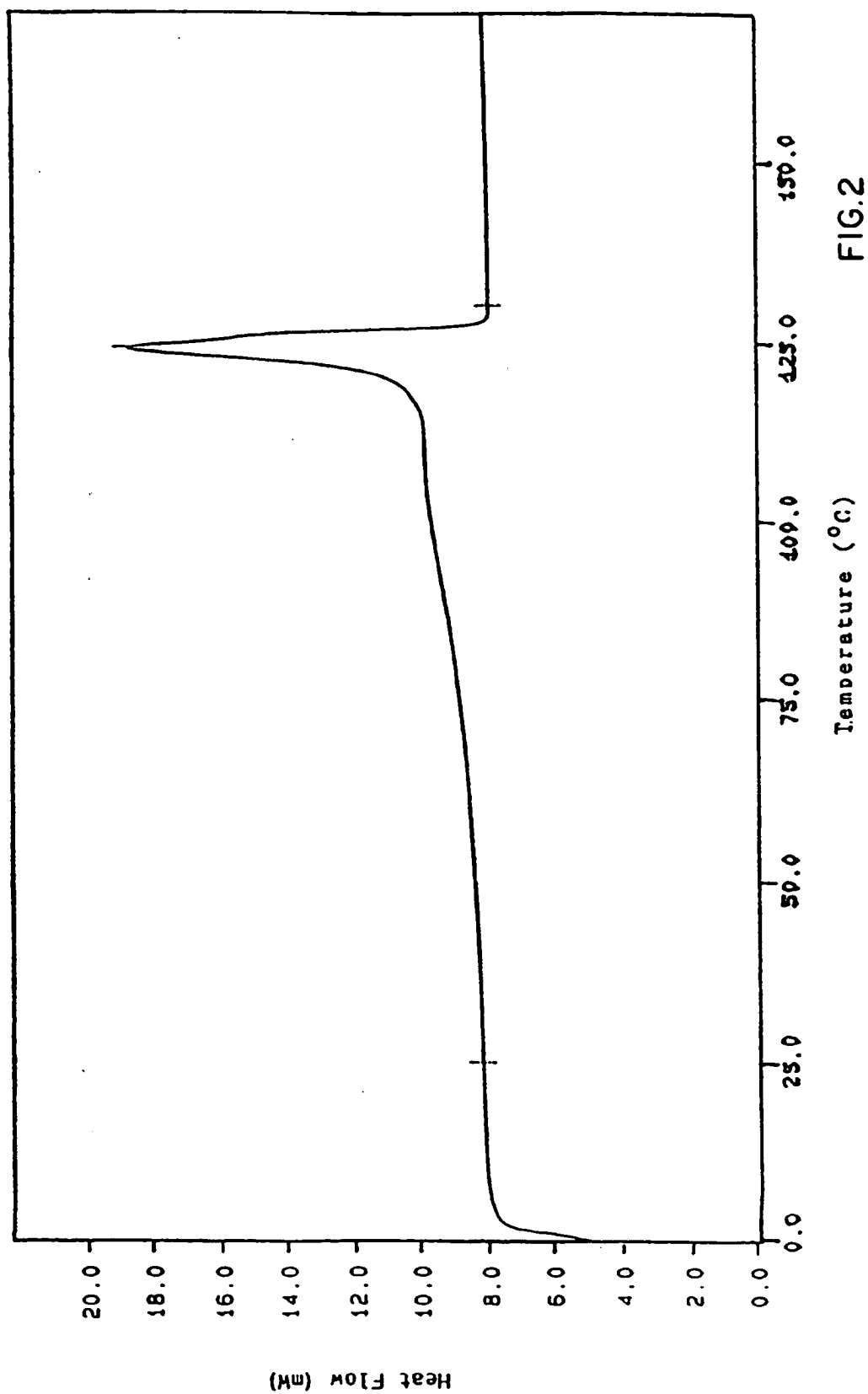


FIG. 2

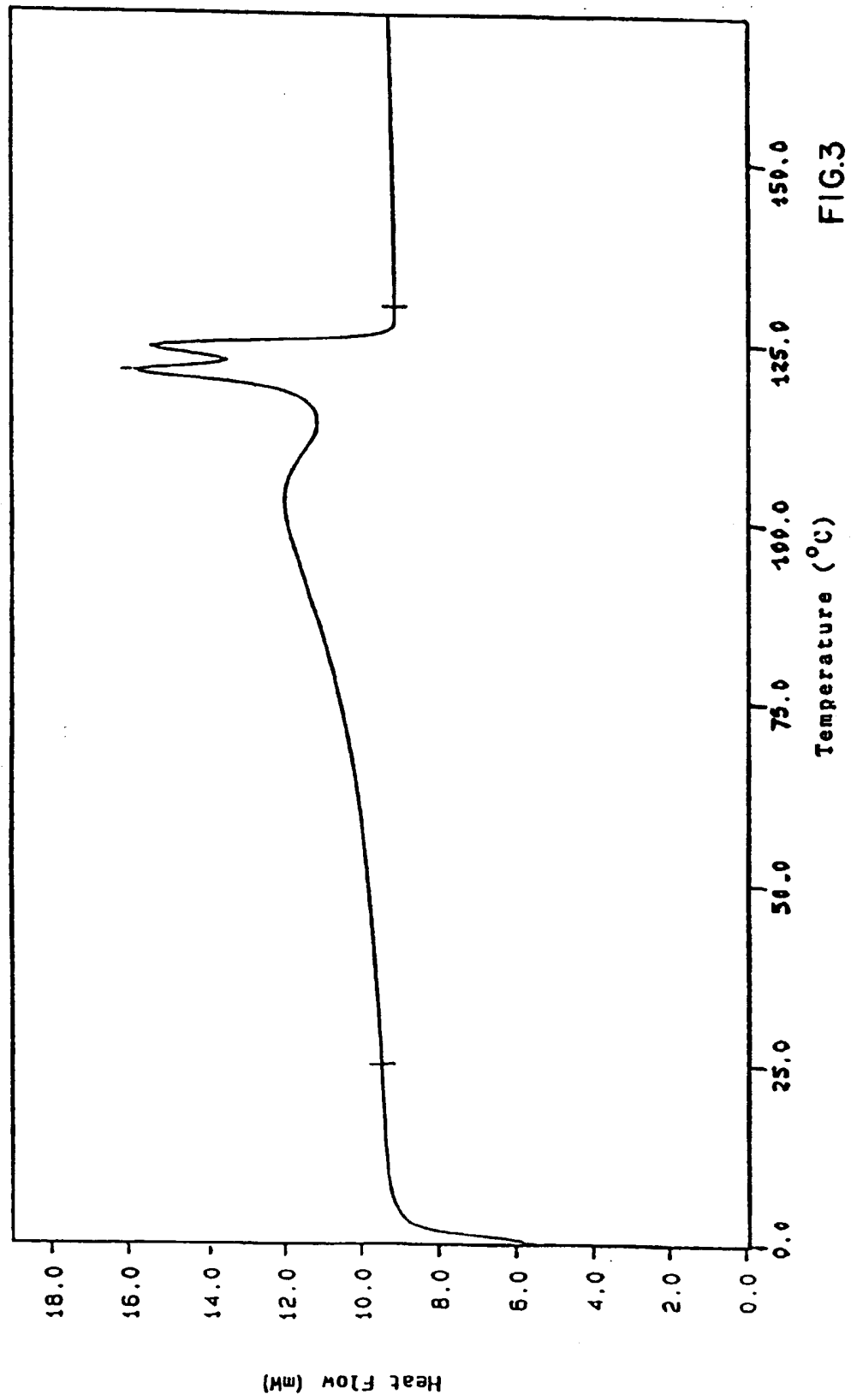


FIG.3

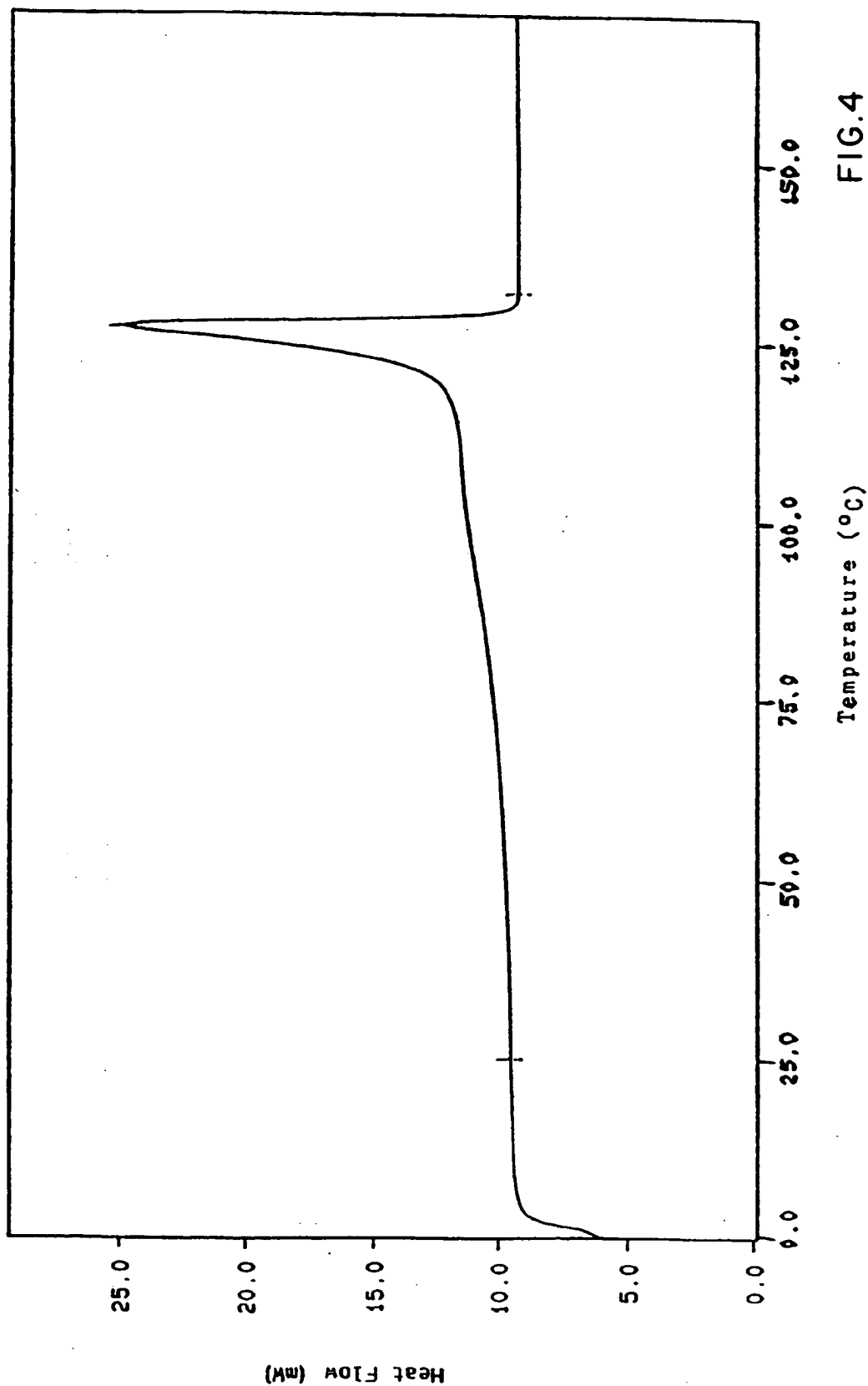
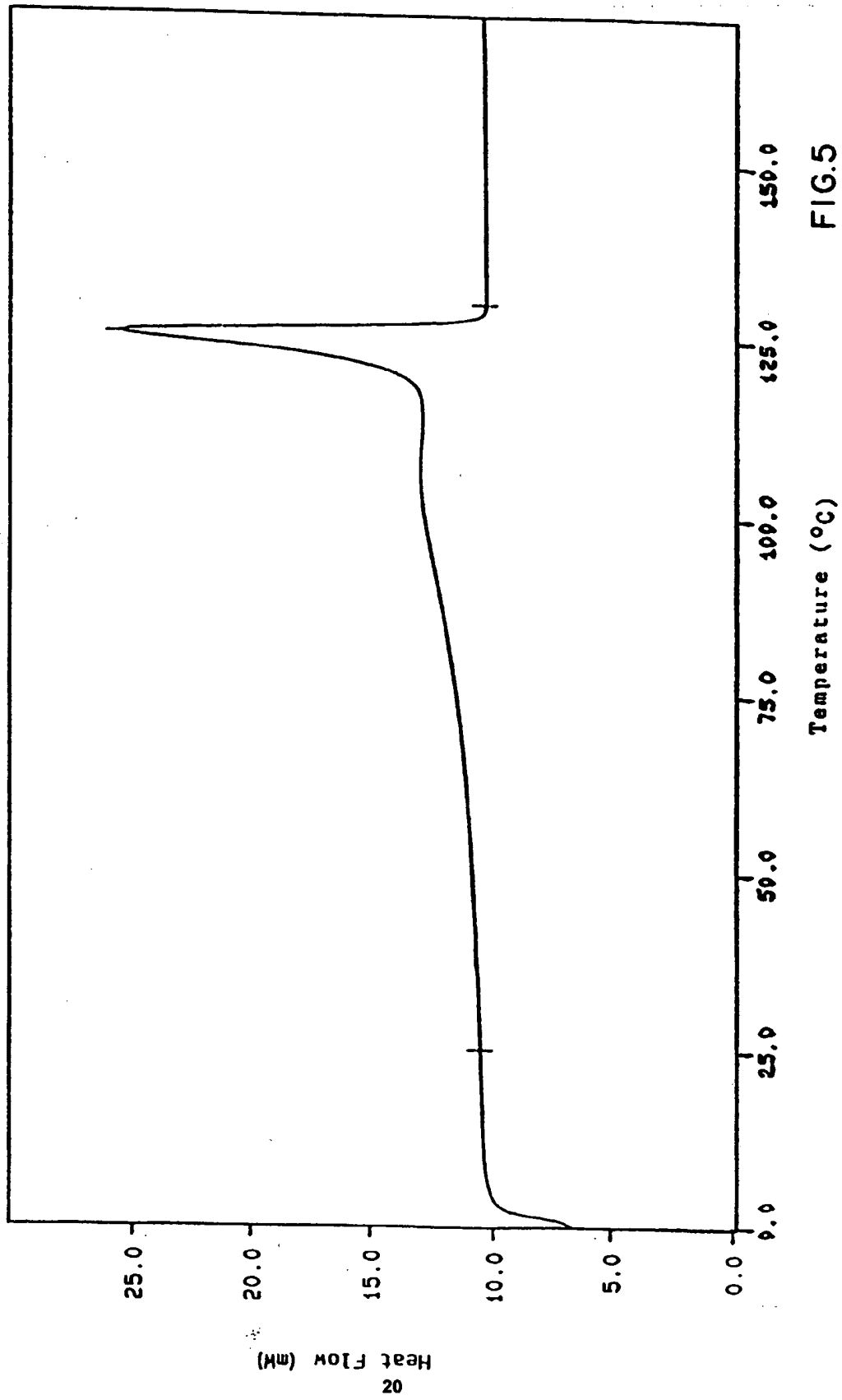


FIG.4



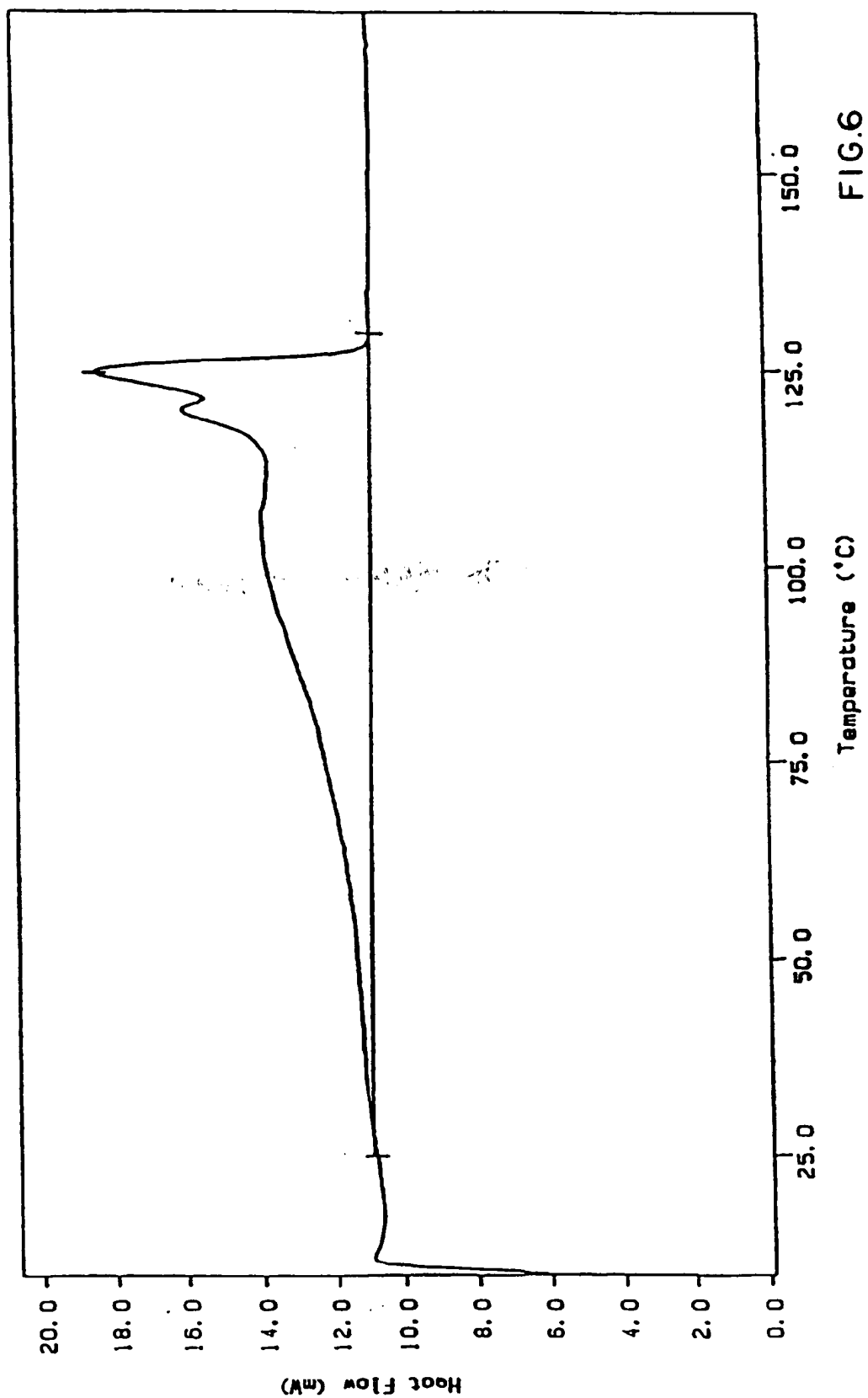


FIG.6

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